

Research Report 1329

12

REVIEW OF METHODOLOGIES FOR ANALYSIS OF COLLECTIVE TASKS

Robert W. Bauer

ARI FIELD UNIT AT FORT KNOX, KENTUCKY

ADA 130971

DTIC FILE COPY



U. S. Army

Research Institute for the Behavioral and Social Sciences

May 1981

DTIC
ELECTE
AUG 2 1983
S D D

Approved for public release; distribution unlimited.

83 08 01 630

U. S. ARMY RESEARCH INSTITUTE FOR THE BEHAVIORAL AND SOCIAL SCIENCES

**A Field Operating Agency under the Jurisdiction of the
Deputy Chief of Staff for Personnel**

**JOSEPH ZEIDNER
Technical Director**

**L. NEALE COSBY
Colonel, IN
Commander**

NOTICES

DISTRIBUTION: Primary distribution of this report has been made by ARI. Please address correspondence concerning distribution of reports to: U.S. Army Research Institute for the Behavioral and Social Sciences, ATTN: PERI-TST, 5001 Eisenhower Avenue, Alexandria, Virginia 22333.

FINAL DISPOSITION: This report may be destroyed when it is no longer needed. Please do not return it to the U.S. Army Research Institute for the Behavioral and Social Sciences.

NOTE: The findings in this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Research Report 1329	2. GOVT ACCESSION NO. A130977	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) REVIEW OF METHODOLOGIES FOR ANALYSIS OF COLLECTIVE TASKS		5. TYPE OF REPORT & PERIOD COVERED
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Robert W. Bauer		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Research Institute for the Behavioral and Social Sciences Fort Knox Field Unit, Fort Knox, KY 40121		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 2Q162722A791
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Research Institute for the Behavioral and Social Sciences, 5001 Eisenhower Ave., Alexandria, VA 22333		12. REPORT DATE May 1981
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		13. NUMBER OF PAGES 49
		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Collective Task Analysis Collective Front-end Analysis Mission Task Analysis		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The state-of-the-art in methodologies for analysis of collective tasks was examined in a literature review and a survey of US Army Centers and Schools. Current concepts and principles in analytic methods were compared. A brief survey of collective analyst personnel at seven Army Centers indicated prevailing analytic activities and needs. An annotated terminology list was included in an appendix.		

Research Report 1329

REVIEW OF METHODOLOGIES FOR ANALYSIS OF COLLECTIVE TASKS

Robert W. Bauer

**Submitted by:
Donald F. Haggard, Chief
ARI FIELD UNIT AT FORT KNOX, KENTUCKY**

**Approved by:
Milton S. Katz, Acting Director
TRAINING RESEARCH LABORATORY**

**U.S. ARMY RESEARCH INSTITUTE FOR THE BEHAVIORAL AND SOCIAL SCIENCES
5001 Eisenhower Avenue, Alexandria, Virginia 22333**

**Office, Deputy Chief of Staff for Personnel
Department of the Army**

May 1981

**Army Project Number
2Q162722A791**

Individual Training and Combat Unit Training

Approved for public release; distribution unlimited.

ARI Research Reports and Technical Reports are intended for sponsors of R&D tasks and for other research and military agencies. Any findings ready for implementation at the time of publication are presented in the last part of the Brief. Upon completion of a major phase of the task, formal recommendations for official action normally are conveyed to appropriate military agencies by briefing or Disposition Form.

FOREWORD

The research reported here is an exploratory examination of the state of the art in methodology for analysis of collective tasks. It is a part of a broader program of research conducted by the US Army Research Institute for the Behavioral and Social Sciences (ARI) and directed toward improved training development for US Army units.

The ARI Field Unit at Fort Knox, KY, conducts research on training methods and training development with an emphasis on improved training for Armor crews and units. Basic to unit training development is the determination of what group behaviors must be trained. Analysis of collective tasks is used to define the collective behaviors needed for successful unit operations. The Army Training and Evaluation Program requirement for unit training development and the recognition that combat proficiency is a function of continuous training within organizations have stimulated thinking about analysis of collective tasks. In the last decade the US Army and its sister services have increased activity in the development of methods and procedures for collective mission and task analysis and the integration of collective and individual tasks. These are ways of conducting what the Army currently calls Collective Front End Analysis or CFEA. Though TRADOC has been working toward a standard method, there is as yet no general consensus on terminology, procedures, purposes and products of CFEA.

This report describes the state of the art in US Army and DoD mission-task analysis and summarizes recommendations for further development of methodology. The results will be of interest to the US Army Training and Doctrine Command, and, especially, the US Army Training Board, in advancing technology in training development.

Accession For	
NTIS GRA&I	<input checked="checked" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By	
Distribution/	
Availability Codes	
Dist	and/or Special
A	

Joseph Zeidner
JOSEPH ZEIDNER
Technical Director



ACKNOWLEDGMENTS

The author wishes to express appreciation for the support and responsiveness of the US Army Centers and Schools at Fort Benning, Fort Bliss, Fort Benjamin Harrison, Fort Knox, Fort Leavenworth, Fort Rucker, and Fort Sill; and special thanks to the staff of the Analysis Division, Directorate of Training Developments, US Army Armor School, Fort Knox, for their exchange of ideas and support throughout this research. Appreciation is also expressed to Specialist 5 Leonard B. Cardwell of the ARI Field Unit-Fort Knox, who analyzed the survey data and made suggestions for interpretation of the results.

REVIEW OF METHODOLOGIES FOR ANALYSIS OF COLLECTIVE TASKS

BRIEF

Requirement:

Though individual task analysis methods and procedures have been developing for some time and are now standardized in the Interservice Procedures for Instructional Systems Development (ISD), the methodology and procedures for analysis of collective tasks have received only belated attention. Collective analysts complain that there is little or no guidance and no relevant training available to support their efforts in the US Army Centers and Schools. Among the services and within the Army there seems to be no consensus on the purposes, approaches or terminology for analysis of collective tasks. This exploratory research was conducted in order to define the methodological problems in collective task analysis and to provide information for decisions about further research and development in methodology, procedures and training for analysis of collective tasks. For the purposes of this preliminary research the scope was limited to methodological aspects of collective analysis. Procedures and training were only incidentally addressed. The scope included basic assumptions, axioms and concepts, including principles of procedural development in analysis of collective tasks.

Procedure:

A literature review of collective task analysis was focussed primarily on US Army methodological developments. However, the sister services and non-military research efforts were also reviewed to add breadth and depth to the conclusions. Basic assumptions, axioms and concepts were developed by analysis of current methodologies and procedures. An annotated terminology list was developed from the literature. A brief survey of analyst activities and needs solicited 17 responses from among seven US Army Centers and Schools. The survey results and the analysis of methods were used to develop statements of problems and principles.

Findings:

Comparison of different methodologies indicated some common techniques, but little agreement on basic concepts, terminology or even products of collective analysis. Collective task analysis was generally closely linked to unit mission analysis and the prevalent approach was top down (from mission to task), but there were wide differences in intervening analytic steps and approaches. One exception to the mission related approach was small crew task analysis, which was, at least in part, often derived from individual task analysis. Survey results indicated that most collective analysis in the seven Army Centers was done for the purpose of new training and evaluation development, primarily for battalions and subordinate echelons. Analysts and supervisors of analysts expressed a preference for a methodology that was useful/relevant and simple. None of the 17 job incumbents who responded to the survey reported receiving any training specific to collective task analysis.

Utilization:

Results will be used by the US Army Training and Doctrine Command and by US Army Centers and Schools in their development of collective mission-task analysis procedures. Information will form a basis for decisions about further research and development in methodology, procedures and training for analysis of collective tasks.

REVIEW OF METHODOLOGIES FOR ANALYSIS OF COLLECTIVE TASKS

CONTENTS

	<u>Page</u>
SECTION I. Introduction	1
SECTION II. Review of US Army Methods for Analysis of Collective Tasks	4
Analysis of Current Methods	4
Assumptions and Axioms	7
Assumptions	7
Axioms	10
SECTION III. Survey of Collective Analysis Activities	13
Survey Procedure	13
Survey Results	13
SECTION IV. Critical Problems in Analysis of Collective Tasks	18
Mission and Task Concepts	18
The Critical Collective Task Concept	21
Complex Tasks and Step Sequences	22
Quality Control in Collective Task Analysis	23
Training for Collective Analysts	24
SECTION V. Discussion and Conclusions	26
Terminology and Concepts	26
Analysis Objectives, Results, and User Participation	26
General Principles in Analysis of Collective Tasks	27
REFERENCES	30
APPENDICES	
Appendix A. Annotated Terminology for Analysis of Collective Tasks	33
Appendix B. Brief Survey on Analysis of Collective Tasks	46

TABLES

	<u>Pages</u>
Table 1. Comparison of Collective Analysis Methods.	8
Table 2. Hierarchy of Priority For Cross-validation of Collective and Individual Tasks. (Adapted from Blau et al., 1980).	11
Table 3. Purposes, Mean Ranks (\bar{x}) and Number (n) of Respondents Who Ranked Each Purpose.	15
Table 4. Organizational Focus of Collective Analysis Efforts. Mean Rank Order (\bar{x}) and Number of Respondents (n) Ranking Each.	16
Table 5. Criteria of Merit For a Proposed Methodology in Order of Mean Ranks.	17
Table 6. Analysis of CCH With Respect to Battlefield Functions and Tasks (From USA Armor Center, 1980).	20

FIGURES

Figure 1. Five basic steps of the CFEA model. (TRADOC, 1981)	2
Figure 2. Purposes ranked first, second and third by survey respondents.	14
Figure 3. Frequencies of first rank choices and second rank choices of criteria for a "good" methodology for analysis of collective tasks.	17

REVIEW OF METHODOLOGIES FOR ANALYSIS OF COLLECTIVE TASKS

SECTION I. Introduction

Until the last decade there was little thought given to methods and procedures for analysis of unit jobs and tasks. For a somewhat longer time, a larger literature has been developing on analysis of individual jobs and tasks. Techniques for cluster analysis of jobs have been developed specifically for the purpose of analyzing jobs (e.g., the Systematic Approach to Multi-dimensional Occupational Analysis (SAMOA) developed by Silverman (1966) for the US Navy). Standardization of individual task lists has been attempted by developing job analysis terminology with lists of work methods verbs and lists of work fields (US Department of Labor, 1975).

The US Army has made a considerable effort to institutionalize the Inter-service Procedures for Instructional Systems Development, known as the ISD model (1975), of which the first phase is titled Analyze. Army analysts who have had training and experience in the ISD approach indicate that it is not applicable to the analysis of collective tasks. However, it is in the ISD individual job and task analysis procedures that many collective analysts have had their only training.

The Army Training and Evaluation Program (ARTEP) approved for Army-wide implementation in 1975 stimulated considerable interest in collective analysis methods and procedures. The US Army Training and Doctrine Command (TRADOC) was given specific responsibility for publishing guidance for ARTEP development and for sponsoring and conducting studies and research projects concerning ARTEP. The TRADOC Reg. 310-2 (1976, 1979) called for comprehensive mission and task analysis as a basis for ARTEP development. TRADOC sponsored some work by SofTech, Inc. on the development of methodology for analysis of Army training, testing and evaluation programs (SofTech, Inc., 1976). TRADOC also sponsored work by Battelle Laboratories on integration of collective and individual front end analysis (Blau, T. H., Kaufman, R. and Morgan, R. M., 1980). SofTech provided a technique for modeling a complex system in order to understand it and communicate it in a series of diagrams -- a technique called Structured Analysis and Design Technique (SADT). SADT was essentially a form of multi-level flow charting which incorporated inputs, controls, outputs and mechanisms in each box and also demonstrated a way of displaying the successive "decomposition" of boxes into their component parts. The Battelle Laboratories paper presented an outline of "collective front end analysis" and "individual front end analysis" (CFEA and IFEA) and proposed means of integrating the two. The integration consisted of a cross-check of individual tasks against collective tasks to determine whether the individual tasks provided necessary support for critical collective tasks and critical missions.

During 1980 and 1981 TRADOC refined a draft publication intended to provide guidance in CFEA for development of ARTEP. This became TRADOC PAM 310-8, 25 Sep 81. An earlier draft version used the Structured Analysis and Design Technique (SADT) developed by SofTech and reiterated much of the flow chart model developed by SofTech. In the current version the SADT was eliminated in favor of a simple five step sequential flow chart as shown in Figure 1 (TRADOC, 1981).

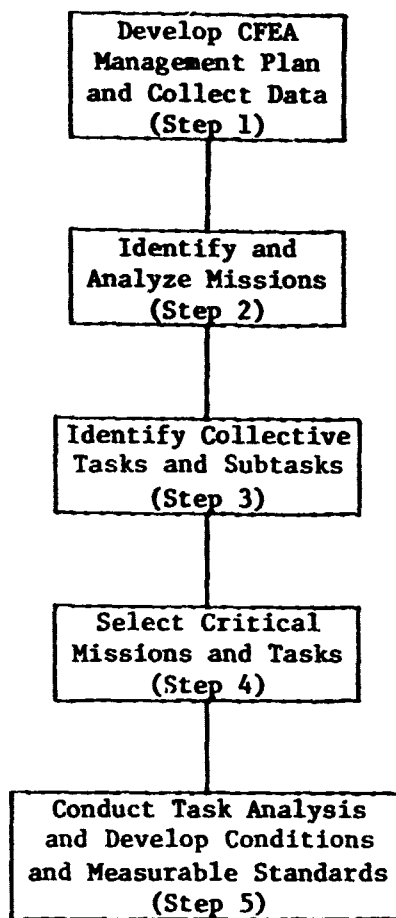


Figure 1. Five basic steps of the CFEA model. (TRADOC, 1981)

These TRADOC methods along with others will be reviewed in more detail in Section II. It is apparent that within TRADOC collective task analysis has become an essential part of Collective Front End Analysis (CFEA). CFEA is a form of mission and task analysis which produces as its result a set of missions and associated tasks with indicators of criticality on both, defined conditions and, if possible, measurable standards.

Despite the fact that TRADOC requirements are very rigorous and specific in certain respects, discussions with TRADOC analysts indicate no consensus on appropriate methodology or procedures for analysis of collective tasks at this time. The need for methodology, procedures and training is especially felt at the training development directorates and centers which have been delegated responsibility for collective analysis but find that they lack specific guidance or trained personnel to do the job. TRADOC PAM 310-8 has responded to this need, but the need is still expressed by TRADOC analysis managers and analysts. It will be discussed further in Section III of this report.

This research is directed toward the long term goal of closing the gap in methodology, procedures and training for analysis of collective tasks in military units. The more immediate objective of this report is a review of current methodology for analysis of collective tasks (ACT) as a basis for further developments. The scope of the ACT methodological problem addressed here is limited to:

- a. analysis of unit mission activities.
- b. identification of collective tasks.
- c. selection of critical tasks.
- d. preliminary identification of job performance measures, i.e., dimensions and standards.

Analysis of existing courses of instruction will not be specifically addressed here, nor will the selection of instructional setting (the last two of the five blocks under Phase I Analyze in the ISD model). (TRADOC, 1975).

Methods developed by and for the US Army for analysis of collective tasks in combat units are focal in this report. However, methods of collective analysis developed in the sister services and methods recommended in the civil literature are also reviewed to add breadth and depth.

SECTION II. Review of US Army Methods for Analysis of Collective Tasks

This section is concerned with US Army methods for analysis of collective tasks. The review is made up of two parts; (1) an analysis of specific methods and procedures currently available for Army use, and (2) a general statement of assumptions and axioms in military collective task analysis.

Analysis of Current Methods

The HumRRO report of 1975 and ARI draft report of 1981 appeared to be closely related but not identical in analysis methodology (O'Brien, R. E., Kraemer, R. E. and Haggard, D. F., 1975; Drucker and O'Brien, 1981). A common author (O'Brien) and much common terminology were found in both. The 1975 procedures involved a top-down (mission-derived) unit task analysis. The 1981 method involved a similar mission-derived process extended to break out certain individual tasks, including leadership tasks, and relate the individual tasks to unit tasks. These reports were unique in relating an unit mission analysis to its supraordinate unit mission, i.e., in order to analyze platoon missions, a prior analysis of the company-team missions was considered necessary. Neither the 1975 paper nor the 1981 paper put emphasis on quality control. The 1975 paper did provide for Subject Matter Expert (SME) review in a survey and follow-up interviews on the task inventory. A Step 8 titled Quality Control was mentioned. However, this step was not detailed in the report. The 1981 report gave no attention to quality control reviews external to the analytic team. The primary unit in the 1975 paper was the company, and the collective analysis proceeded down to the platoon level. The crew tasks which were detailed appeared to have been derived from individual task analysis products selected as requiring coordination at the platoon level and supporting the platoon (company) major mission operation. A similar method was explicitly followed in the 1981 effort to develop crew tasks in support of platoon operations. The primary unit of analysis was the company-team even though the focus of interest was on the platoon leader and the platoon (as basis for development of platoon drills). The mission analysis did not proceed beyond the platoon level. However, crew tasks and individual crewman tasks were assembled in support of various platoon operations and team operation phases. The identification of crew tasks by examining aspects of an operation apparently requiring coordination among crewmembers is similar to the process used by the Air Force in crew coordination analysis. (Cream, B. W., 1974; Cream, B. W., Eggemeier, F. T. and Klein, G. A., 1978).

ARI identified crew coordination tasks in helicopter nap-of-the earth (NOE) flight in a similar way (Gainer, C. A. and Sullivan, D. J., 1976). However, this aircrew analysis was mission-based, proceeding from the top down. The collective task situations were defined in battle scenarios, which described the terrain, deployment and resources of both friendly and enemy units. Mission scenarios were then developed for four classes of Army missions, anti-Armor, ground troop support, reconnaissance and medevac. Scripts and mission profiles were then prepared. The main sections of the mission profile were designated as mission phases and these, in turn, were divided into

segments. Aircrew functions necessary to accomplishment of each mission segment were then identified. A "function" was defined as a single action or a set of actions that produces a coherent outcome that is essential to the successful performance of a mission segment. Only after this exhaustive breakdown were tasks identified at a very specific level.

No larger unit (than crew) was considered. The authors did do repeated checks with subject matter experts as the analysis proceeded; the approach was described as a series of surveys and analyses. One major quality control review of training objectives and task data occurred near the completion of the research.

This analysis was very detailed. A total of 20 segments, 139 functions and 1,078 tasks were identified in NOE flight. These tasks were so specific that they might have been called steps within subtasks in another analysis. They were a mix of individual and crew coordinated tasks.

The Battelle Laboratories methodology was an effort to provide means for the coordination of collective and individual front end analyses (Blau et al., 1980). The principal bases were the Job and Task Analysis Handbook (TRADOC PAM 351-4 (T) TRADOC, 1979) and the TRADOC PAM 310-8 (DRAFT) TRADOC, 1980, the latter in an early version. The Job and Task Analysis Handbook was used as a reference on Individual Front End Analysis (IFEA) and the draft PAM as a reference on Collective Front End Analysis (CFEA). Since the approach is slightly different from the latest PAM 310-8, it will be worthwhile to examine the Battelle paper briefly before taking up the PAM.

Like the HumRRO approach this methodology is top-down, mission-derived. However, the mission analysis began with the unit of principal interest, i.e., the primary unit was the focal unit. Further, there was great emphasis on quality control. Frequent check-points involved board reviews of the interim products of analysis. Another emphasis was on scaling and measurement. The authors recommended the use of interval or ratio scaling, wherever possible, and included checks for measurability among the quality controls. Measurability was recommended in considerations of threat and functions as well as in development of standards. Missions were analyzed by decomposition into components, and these were further broken down into action sequences performed by subordinate echelons. The authors defined a unique unit of analysis, a function as " . . . NOT a collective task. A function is a collection of products, or results, which combine rationally together to yield a common product or result. If you sum up tasks, you will get functions. If you sum up functions you will get missions, . . ." The insertion of function analysis as a bridge between mission analysis and collective task analysis was intended to assure that collective tasks could be stated as discrete, measurable units of performance. (This was similar to O'Brien's earlier use of Major Mission Operations (MMOs) as components of missions. Duties, tasks and subtasks derived from a timeline analysis of an MMO became the collective task list for the MMO.)

Since the functions in the Battelle approach were allocated to echelons and the task analysis, including the identification of critical collective tasks, conditions and standards, followed upon function analysis, it appears that the mission of the supraordinate and focal unit is broken down into the functions and tasks of the subordinate units. This is different from the HumRRO/ARI approach, which developed the missions and tasks of the focal unit out of the supraordinate unit mission analysis.

The Battelle paper did not clearly indicate the manner in which successive echelons are to be analyzed, e.g., battalion--company--platoon. In fact the paper did not make clear what echelons were addressed, though the collective training analysis algorithm and the mention of ARTEP suggested that the battalion was probably focal. Of course, the integration of individual analysis with collective analysis was specifically addressed. The method recommended was an OMNI Linkage System Algorithm, a network of personnel and linkage forms which provided a record of the cross-checks of individual tasks and collective tasks. The auspicious name of this system was not supported by an equally clear and meaningful system. The integration model consisted essentially of three flow charts, three administrative record forms, and a few paragraphs of discussion. The record (linkage and evaluation) forms appeared to be somewhat obscure and irrelevant to the actual task. After completion, these forms would, presumably, be placed in the analysis audit file, and rarely retrieved. Two pertinent recommendations were noted in the Integration section. These were (1) the insistence upon a cross-check on a collective/individual interface matrix, and (2) the identification of key points in both individual and collective front end analysis where integration actions were considered necessary.

The current TRADOC effort in collective task analysis is the revised TRADOC PAM 310-8, 25 Sep 81, which was intended to be a guide to assist analysts in the conduct of a Collective Front End Analysis (CFEA). In this document there was an emphasis on observable and measurable terms in standards, and at the end of each task analysis, a review with Subject Matter Experts. ". . . to insure that the performance is measurable, reliable and valid . . ." However, the PAM did not include the Battelle Laboratories' insistence on interval or ratio scaling. The PAM further emphasized the development of drills ". . . around the lowest unit echelon (team, crew, section, squad) . . ." as a training strategy in integrating individual and small unit skills in preparation for ARTEP.

A sample Standing Operating Procedure was included. This organized the five major steps (Figure 1) into actions and products in a reasonably clear and objective manner. Though it was not entirely clear at what command or echelon level missions and collective tasks should be defined, the pattern of analysis resembled the Battelle Laboratories' model more than the HumRRO model. The missions and tasks of the focal unit were apparently defined by breaking down the functions and tasks of the subordinate units. The concept, function, was not used with the same meaning as in the Battelle Laboratories' paper. Concept terminology remained problematic in that some terms, such as function were used in the text but were not defined. Other terms, such as critical missions/tasks and standard were defined either in a circular manner or in a

vague way not very helpful to the working analyst. Definitions of terms were interspersed in the text and also in an appended glossary. (A more detailed comparison of terminology is in Appendix A.)

A comparison of the principal US Army methods of collective analysis is presented in Table 1.

Assumptions and Axioms

This section presents assumptions and axioms commonly found in available guidance for analysis of collective military tasks.

While an assumption is a supposition or postulate which is supposed or taken for granted, often implicitly, an axiom is similarly an established or widely accepted proposition proposed for the sake of studying the consequences that follow from it, and more often explicit, in logic and mathematics. The distinction is not always clear, especially if the assumption is explicit, in which case it may be treated as an axiom and inferences (corollaries) drawn from it.

Assumptions

Throughout the military literature on analysis of collective tasks, the following assumptions are generally present.

Assumption 1. Analysis of collective tasks is primarily a mission-derived, top-down process.

In the HumRRO and ARI papers the derivation of task analysis from mission analysis was explicit, a logical extension of the close relationship between individual task analysis and job analysis. (HumRRO, 1969; O'Brien et al., 1975; Drucker and O'Brien, 1981). In the TRADOC literature the mission-derivation of collective tasks became an assumption, sometimes unstated, sometimes stated. The HumRRO and ARI work was not cited. The process of analysis of collective tasks became an integral part of a mission-task analysis process called Collective Front End Analysis (CFEA). As stated in the TRADOC TP, "During the CFEA, the analyst identifies and analyzes the missions and collective tasks necessary to accomplish the unit's overall mission." This leads directly to Assumption 2 below.

Assumption 2. Analysis of collective tasks is an integral part of a process of unit mission and task analysis, sometimes called Collective Front End Analysis (CFEA).

This label may be an unfortunate choice in that CFEA has been used with different meanings in different contexts. In this context CFEA ordinarily included the analysis of the unit (Table of Organization and Equipment (TOE)) capability, unit missions and tactical doctrine in order to determine critical missions and critical tasks along with task conditions and standards. (Blau et al., 1980; TRADOC, 1981).

TABLE 1. Comparison of Collective Analysis Methods.

<u>CONTENT/APPROACH</u>	<u>SOURCE</u>				
	<u>HumRRO</u> <u>1975</u>	<u>ARI</u> <u>1976</u>	<u>ARI</u> <u>1981</u>	<u>Battelle</u> <u>1980</u>	<u>TRADOC</u> <u>1981</u>
Included management plan	0	+	0	0	+
Included audit trail	0	0	0	+	+
Mission derived approach	+	+	+	+	+
Mission hierarchy	+	0	+	0	+
Related threat to performance	0	+	0	+	0
Integrated supraordinate unit	+	0	+	0	0
Integrated subordinate unit(s)	+	0	+	+	+
Integrated individual tasks	0	+	+	+	+
Analysis by decomposition	+	+	+	+	+
Intervening levels of analysis between mission and task (n)	1 ^a	3 ^b	4 ^c	1 ^d	0
Used SME validation	+	+	0	+	+
Other quality control checks included (n)	0	1 ^e	0	3 ^f	1 ^g
Criteria for criticality objective and/or operational	+	+	0	0	+
Task standards and/or criteria operational	+	+	+	+	+
Terminology defined in text	+	+	+	+	+
Glossary included	+	0	0	0	+

^aMajor mission operation

^bMission phase → mission segment → aircrew function → task

^cTeam mission phase → team operation → team operation phase → platoon operation → platoon task

^dFunction

^eTraining objectives and task analysis data reviewed by operational units and by flight instructors.

^fBoard Reviews of (1) missions and missions criticality; (2) function and task analysis; (3) scales and standards for critical tasks

^gBoard Review of critical and non-critical mission and task lists

Assumption 3. Analysis of collective tasks may be performed on military organizations ranging in size from a crew or platoon up to a division, including variations like combat teams.

Though the focus of CFEA efforts appears to be upon Army Training and Evaluation Program (ARTEP) development for battalions, there are readily available examples of analytic efforts directed toward division activities, platoon tasks and crew tasks developments. (TRADOC, 1981; TRADOC, 1979; Drucker and O'Brien, 1981; Gainer and Sullivan, 1976.)

Assumption 4. Analysis of collective tasks is a linear (sequential) procedure.

This is a simplifying assumption permitting the prescription of orderly procedural steps for analysis of collective tasks. The Instructional Systems Development (ISD) Model for individual task analysis, which made the same assumption, is a common element in the background of the analysts and developers active in collective analysis. Structured Analysis and Design Technique, which offered a three-dimensional potential in its graphic "structured decomposition," is described by SofTech as a "way that allows a complex system to be understood one step at a time" . . . "an organized sequence of "blueprint" drawings." (SofTech, Inc., 1976). Thus, the potential for a multi-dimensional approach seems to have been sacrificed in part for linear (or, at most, two-dimensional) simplicity. This model appears to have influenced the more recent TRADOC developments. (Blau et al., 1980; TRADOC, 1981). But this influence has not changed their essentially linear, procedural character.

Assumption 5. Only certain units (and mission classes) will be selected for analysis of collective tasks -- these may be established units or conceptual units -- and unit selection will be made by senior decision makers. This unit selection is not itself necessarily a part of the analysis process.

This assumption springs from the prevailing attitude that analysis of collective tasks is itself a rare, time-consuming and difficult task and will be performed only as required. There is some explicit guidance for the selection of TOE units and missions for analysis in TRADOC REG 310-2, 10 Dec 79, which is concerned with ARTEP development. Interpretation of this guidance indicated that the units and missions selected for analysis involved predominantly the MOSs for which the particular integrating center was proponent.

In other current guidance (TP 310-8) the implication is clear that at least initially: all missions must be considered, including TOE missions, supporting missions, and both explicit and implied missions. Since each unit mission is probably unique in some respects and the total number of possible missions is very large, the analyst may be left with the problem of determining the most common or essential mission classes for detailed analysis. The guidance for mission selection in TRADOC REG 310-2 gave high priority to consequences of inadequate mission performance for (1) survival, and (2) TOE mission accomplishment. These criteria, especially the latter, are more logically applied to lower echelon missions in relation to supraordinate missions, e.g., what are the consequences of inadequate performance of company mission x to battalion mission y? Obviously, to ask -- What are the consequences of inadequate performance of battalion mission y to battalion mission y? -- is hopelessly circular.

Axioms

The following axioms, like the assumptions above, are held as postulates for the time, in order to further examine their implications or consequences. However, these are more often than the assumptions above, stated explicitly in current literature.

Axiom 1. The immediate purpose for analysis of collective tasks is the identification of unit activities. However, the analysis products are intended for several longer range purposes. (Blau et al., 1980; TRADOC, 1981; Drucker and O'Brien, 1981).

In ISD (individual task analysis) terms, "The analysis phase in the instructional process determines exactly what constitutes adequate on-the-job performance. When completed, . . . will provide information about what tasks must be performed, in what manner, under what conditions, in response to what cues, and to what standards." (US Army Armor Center, 1978). However, the more general and long range purposes for collective analysis may conceivably include: (1) the development of training programs or training devices; (2) the development of evaluation instruments; (3) reorganization of units; (4) determination of doctrine; and (5) the cross-validation of collective tasks with individual tasks.

A corollary to the axiom above is that different purposes for analysis of collective tasks may require different analysis products -- implying some variation in procedures. A second corollary to the first axiom is that such variance in procedures implies a general, adaptive methodology for analysis of collective tasks, if not more than one methodology.

Axiom 2. The process of analysis of collective tasks includes quality assurance procedures at more than one point. (Blau et al., 1980; TRADOC, 1981).

Some available procedures indicate check points not only at the conclusion of collective analysis, but at other points in the process. Thus a first corollary to axiom 2 is that check points will be identified at several appropriate points in the analytic process. These quality assurance procedures usually involve reviews by a special board, though the review board constitution and procedures are not always spelled out for the analyst. A second corollary to axiom 2 is that each check point for quality assurance will involve an operational (objective, recorded) procedure yielding relatively reliable and valid indications of quality. Such indications may include accuracy, comprehensiveness, understanding and acceptance among others. The second corollary is inferred directly from the emphasis on quality assurance procedures and the repetitive, cumulative nature of the analysis activity. For example, if a review board is to be used to provide quality assurance, there must be a systematic effort to insure that the board is made up of well qualified individuals and that the board's operations are well-defined and recorded.

Axiom 3. The process of analysis of collective tasks includes definition of critical tasks, and for these critical tasks, task conditions and task standards. (TRADOC, 1981).

The concept of critical tasks is often identical with selection for training and evaluation. Since collective analysis is frequently done for ARTEP development, it has been said that critical tasks are those included in the ARTEP. After appropriate ARTEP development, this proposition may be accurate; however, in the process of analysis and training development it is more appropriate to say that critical tasks are those according with specified criteria, and therefore, chosen to be included in the training. (See Axiom 6 on selection of tasks for training.)

Task conditions may be derived from the mission situations, usually including terrain, weather and threat. (TRADOC, 1981). Some authors suggest consideration of mission characteristics, enemy threat, terrain and weather and available troops (METT). (Drucker and O'Brien, 1981.) Presumably mission characteristics include threat if threat is not specifically mentioned.

The combination of critical tasks with training conditions and standards makes up training objectives.

Axiom 4. Only selected unit tasks will be cross-validated against individual tasks to determine consistency and supportability of collective tasks. (Blau et al., 1980).

There has been little coordination between collective and individual analysis in most centers. This may be partly because the proponentcy for the ARTEP development does not correspond to the proponentcy for many supporting job specialties. The collective analyst rarely does the non-proponent cross-checks. In any case, the integration of collective and individual tasks is time consuming and expensive. This proposition is developed in the referenced Battelle Laboratories paper, along with its corollary, that priorities must be established for determining those jobs which should, as an absolute minimum, be cross-validated. The Battelle paper offered a hierarchy of priority as in Table 2 from high priority to low.

TABLE 2. Hierarchy of Priority For Cross-validation of Collective and Individual Tasks. (Adapted from Blau et al., 1980).

High Priority	↑	Command	}	Careful crosscheck on interface matrix
		Leader/Supervisory		
		Combat Critical Jobs/Duties		
		Critical Team and Individual Tasks		
Low Priority	↓	Less Critical Tasks	}	Perfunctory or no interface checks
		Standard Housekeeping Support (in field or operational mode)		
		Logistics/Housekeeping (in garrison)		

Axiom 5. Collective task standards must be operational, i.e., stated in precise, observable, measurable terms. (Blau et al., 1980; TRADOC, 1981).

The Battelle paper recommended that performance standards -- indeed all requirements, including threat -- be written in interval or ratio scale terms, and called for quality checks to assure measurability of standards. In their words, ". . . the performance standards will be stated as exact, measurable and detailed criteria." In their discussion of performance objectives they indicate, "Such objectives should include both general intentions of results (goals) as well as detailed objectives which should be measurable on an interval or ratio scale." The TP 310-8 did not specify the kind of scaling to be used but it did call for explicit measures. "If it is a product, the standard is defined in terms of accuracy, tolerance, completeness, format, clarity, errors, or quantity. If the standard is a process, it is defined in terms of sequence, completeness, accuracy, or speed. Both product and process must be observable and/or measurable."

Axiom 6. The primary criteria for selection of tasks for training development (critical tasks) are: (1) Is good performance necessary for mission accomplishment? (2) Is good performance necessary for unit survival? These are also primary considerations in the definition of task standards.

While these two remote criteria are often explicit in the literature, it is not always clear how they will be related to the longer list of more immediate product and process dimensions usually suggested for standards. Furthermore, if these two criteria are used for selection of critical tasks, it is questionable whether these critical tasks are also to be selected for training. An argument can be made for pretesting to determine proficiency, and then, only if a deficiency is found, providing training to the standard. A task performance exceeding the standard might indicate no need for further training at this time. In another approach the test performance is part of the training, so that repetition of the training along with appropriate feedback of results and instruction would almost invariably lead to proficiency.

Another consideration is that critical tasks may have importance other than in relation to training, e.g., for assessment of doctrine, system design or unit composition. Such applications transcend the definition of a critical task as a task selected for training.

SECTION III. Survey of Collective Analysis Activities

Survey Procedure

In order to gain a better understanding of current practices, purposes and training in analysis of collective tasks a brief survey was developed for administration to the US Army Centers where analysis activity was known to occur. Eight questions concerned (1) purposes for analysis, (2) man days expended in analytic activities, (3) organizational units focused in analysis, (4) collective analysis training background of analysts and supervisors, and (5) general criteria of merit for a methodology. (The Brief Survey on Analysis of Collective Tasks is included verbatim in Appendix B.) The survey was provided to analysts and first line supervisors of analytic activities by local ARI scientists at seven US Army Training Centers* throughout the United States during March and April 1981. From one to five appropriate respondents were identified in each Center and all responded to the survey, yielding 17 responses total.

Survey Results

The first question concerned the major purposes for which Army organizations do analysis of collective tasks. Since the respondents were permitted to rank order as many choices as were relevant to their activities, the mean ranks were only meaningful if the number of responses was also considered. Modal choice for first rank in importance was "development of unit training (new)." This purpose was ranked first by seven respondents and ranked second by six. Modal choice for second rank in importance was shared between "development of unit training (new)" and "development of unit evaluation instrument(s)," since both purposes were selected for second rank six times. These two purposes along with the write-in response "ARTEP" (ranked first by two respondents) represented the thrust of ARTEP development, which is intended to unify training and evaluation. Lower rank orders were spread rather evenly among "analysis of existing courses of instruction," "development of unit training devices," and "comparison (matching) of unit and individual training objectives and standards." Figure 2 shows frequencies of choices among the nine purposes for first, second and third ranks.

Table 3 identifies the purposes represented in Figure 2 with the mean ranks and the number of respondents who ranked each purpose.

*Centers and number of responses were Leavenworth (1), Knox (3), Sill (3), Bliss (5), Rucker (1), Benning (2) and Benjamin Harrison (2).

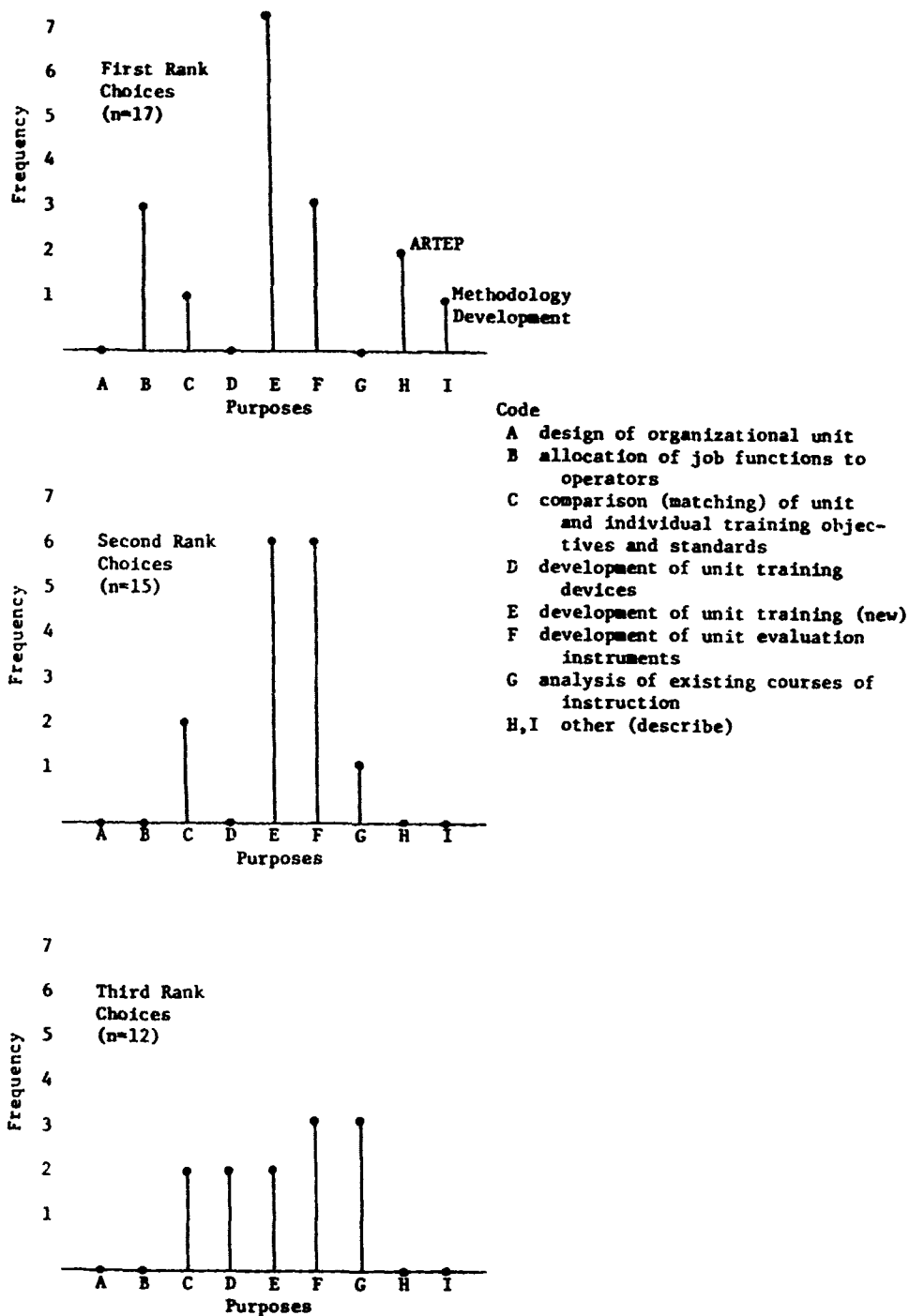


Figure 2. Purposes ranked first, second and third by survey respondents

TABLE 3. Purposes, Mean Ranks (\bar{x}) and Number (n) of Respondents Who Ranked Each Purpose.

Code	Purpose	\bar{x}	n
A	design of organizational unit.	-	0
B	allocation of job functions to operators.	1.75	4
C	comparison (matching) of unit and individual training objectives and standards.	3.12	8
D	development of unit training devices.	3.83	6
E	development of unit training (new).	1.73	15
F	development of unit evaluation instrument(s).	2.00	12
G	analysis of existing courses of instruction.	3.57	7
H	other (describe) . . . (ARTEP)	1.00	2
I	other (describe) . . . (Methodology)	1.00	1

Aside from the training and evaluation thrust identified with ARTEP development, there was some priority collective analysis activity serving a human factors problem, allocation of job functions to operators, and also some emphasis upon matching or integration of collective and individual training objectives and standards.

The second question concerned the number of man days per year spent on (1) procedures development and (2) on analysis and reporting on analysis of collective tasks. Twelve respondents answered this question and indicated that their organization spent about a half man year in procedures development each year (\bar{x} = 125 man days) and about one full man year each year in actual analysis of collective tasks (\bar{x} = 256 man days). More time was given to their highest priority task as indicated in Question one above and somewhat less to lesser priority analyses. Question three related the man days effort to discrete analysis jobs (an organizational unit analysis). Each analysis job required an estimated 272 man days, somewhat more than one staff-person year. Supervisors, who did not themselves do the analysis, estimated less (\bar{x} = 165 man days) and collective analysts estimated more (\bar{x} = 338 man days).

The fourth question concerned the organizational unit upon which the analysis was focused. Modal choices in rank order were battalion (squadron) for rank one, company for rank 2 and platoon for rank three. These again, presumably, reflected the thrust of ARTEP development in its impact on collective analysis activities. Mean ranks and number of respondents ranking each organization are shown in Table 4.

TABLE 4. Organizational Focus of Collective Analysis Efforts. Mean Rank Order (\bar{x}) and Number of Respondents (n) Ranking Each.

	\bar{x}	n
Division	5.00	1
Brigade	3.67	3
Battalion (Squadron)	1.88	17
Company (Troop)	2.13	15
Platoon	2.57	14
Section	2.82	11

The fifth question concerned the training of the collective analysts. All respondents answered the question. The responses indicated reliance on job experience (OJT) in all cases with little or no guidance for half the personnel. Of those 11 respondents who were actually working on analysis of collective tasks, six had received short courses in Criterion Referenced Instructional Development or in the Instructional Systems Development Model. Five of the six supervisors of collective analysts, themselves had no training relevant to the area of collective analysis. Discussions with a few of these respondents indicated that this lack of training was seen as a serious handicap.

The sixth question concerned criteria of merit or value for a proposed methodology. The respondents were asked to rank order all five of the proposed criteria, which were defined as follows.

Economy/Efficiency--Is the methodology reasonably economical? Can procedures be derived and analysis executed in a reasonable time by one or two persons (with minimum training)?

Utility/Relevance--Does the methodology provide guidance useful and pertinent to analysis of collective training?

Simplicity--Is the methodology such that, with minimum training and/or a training aid, the analyst can understand and apply the methodology to derivation of a procedure and analysis of unit operations?

Adaptability--Is the methodology flexible enough that different scopes and procedures can be derived for different analytic purposes?

Acceptance--Will you (or your collective analyst) use this methodology?

All responded and made selections as shown in Table 5. The respondents placed high value on utility and simplicity in collective analysis methodology.

TABLE 5. Criteria of Merit For a Proposed Methodology in Order of Mean Ranks.

CRITERIA	\bar{x}
Utility/Relevance	2.35
Simplicity	2.71
Adaptability	2.94
Economy/Efficiency	3.18
Acceptance	3.82

Figure 3 shows the frequencies of choices among the five criteria for first rank and for second rank.

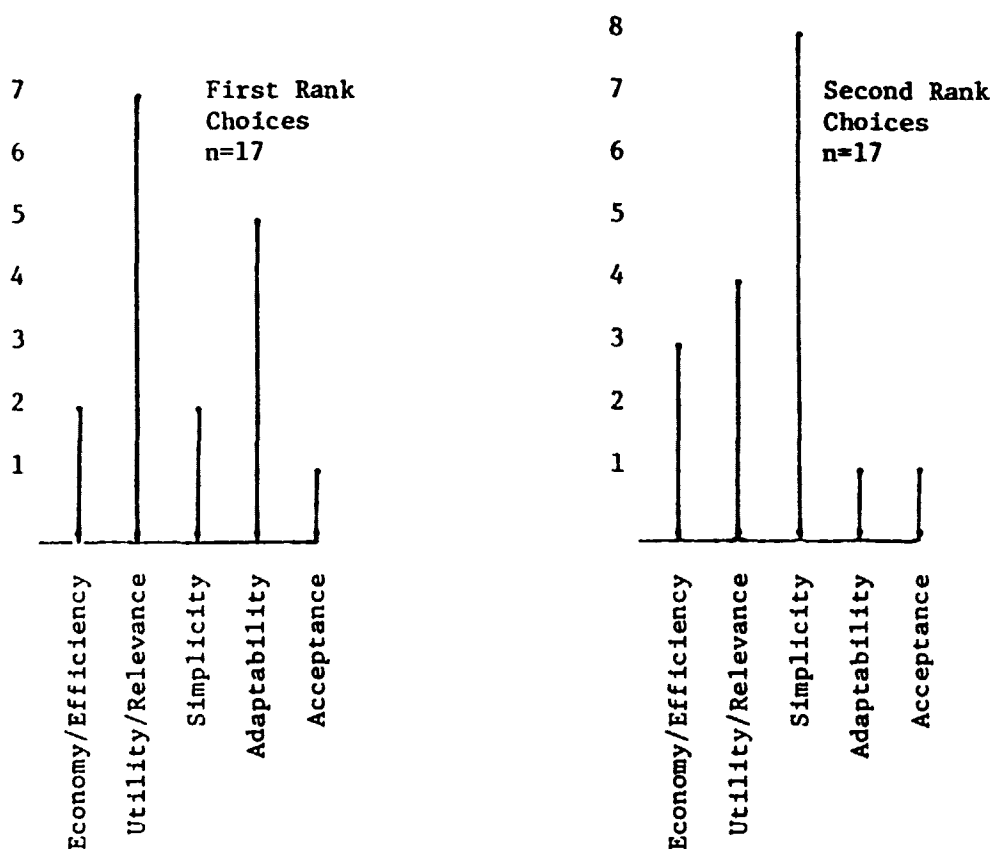


Figure 3. Frequencies of first rank choices and second rank choices of criteria for a "good" methodology for analysis of collective tasks.

SECTION IV. Critical Problems in Analysis of Collective Tasks

Mission and Task Concepts

A brief review of almost any product of collective task analysis efforts will raise questions about the definition of collective task. Lists of collective tasks will be found to contain small group behaviors which can be identified as part-tasks or subtasks of many missions and tasks, crew tasks and individual tasks as well as unit tasks. All of the following examples are excerpted from a list of tank platoon tasks prepared by ARI (Drucker and O'Brien, 1981). The list included what many analysts would consider part-tasks or subtasks, e.g., "Continue appropriate movement," "Continue fire," "Correct speed of tanks." Examples which could logically be construed to be crew tasks or subtasks are, e.g., "Complete after operations maintenance," "Prepare individual positions," "Prepare range cards," "Pop smoke."

These are somewhat confusing when considered in relation to other (crew and individual) task lists. There seems to be no generally accepted lower limit for the reduction of unit tasks so that the distinctions among company, platoon, crew and individual tasks are sometimes blurred in the collective analysis process.

Task definitions usually have a clause referring to an action with a definite beginning and ending and an observable outcome or product. The authors' definition of a platoon task was " . . . any task requiring simultaneous or sequential coordination between two or more tank crews assigned to the same platoon." A collective task was defined as any task requiring simultaneous or sequential coordination between two or more persons or between two or more groups of persons, thus including both platoon tasks and crew tasks at the small group level. Crew tasks were identified by a judgment as to which of the tasks described in the field manuals could be performed only by coordination between two or more members of the same crew.

The problem in identification of collective tasks lies not only in the confusion of definitions available, but also in the concept of a collective or unit task. The concept above, like the TRADOC concept in TP 310-8, made each successive echelon collective task a function of the decomposition of the supra-ordinate unit into its component parts, e.g., platoons broken down into crews, crews broken down into members. This "decomposition" process gained the advantage of displaying the parts (company team operations, phases and platoon operations) making up the mission at the risk of overlooking important characteristics of the larger unit behaviors and confusing discriminations among different echelon behaviors.

A different approach was developed in the ARI work on helicopter NOE requirements (Gainer and Sullivan, 1976). Four missions (classes) were developed into scenarios from which mission profiles (time lines) were drawn. From these (1) mission phases, (2) mission segments, and (3) functions were successively derived, making a total of three levels of analysis between missions and tasks. This yielded tasks at a very detailed level of specificity, but all of the analysis was focussed on the crew level.

A very different approach was implied, but not detailed, in mission-area analysis of large unit operations. (Headquarters, Ft. Monroe, 1979; USA Armor Center, 1980; TRADOC, 1980.) Recent work involved analysis of the missions of concept (Division 86) units. The focus was on areas of influence and areas of interest appropriate for different levels of command. Tasks were considered as necessitated by the threat and characteristic of the specific unit and its resources. Brinkley and Wrockloff, in their Mission Area Analysis, Close Combat Heavy (MAA(CCH)) (U) (USA Armor Center, 1980 (SECRET)) performed what they called a collective front end analysis in order to identify for further analysis those elements for which current or projected combat capability of US Armed Forces was deficient. Their further purpose was to identify opportunities for capability enhancement.

Worldwide threat possibilities were reviewed. The operational concept was developed around a single primary Army mission -- winning the land battle. The Mission Area Analysis concentrated attention on two major missions for Close Combat (Heavy) (CCH):

- (1) To defeat or neutralize enemy combat forces through direct combat power, in a ground environment, through the use of mechanized and armored forces and Army tactical aircraft (Central Battle).

- (2) To generate, sustain, and reconstitute sufficient direct combat power to be able to continue the battle as required (Force Regeneration).

Eight generic battlefield functions were tabulated against nine critical tasks to show the five TRADOC battlefield tasks considered within CCH. See Table 6.

It is interesting that the functions did not serve at an intermediate level of analysis between mission and task, but as cross-referenced generic activities occurring in from one to five tasks in each case. These functions or major components of these functions also recurred in the lists of subtasks provided.

The concept of functions as generic activities, ranging across different collective tasks and occurring as collective subtasks or even tasks at lower levels of analysis, is a useful device for organizing common and recurring activities. Thus activities like "Engage targets" or "Obtain information/communicate" which may recur within many large unit tasks, can be identified as functions within such tasks and also as tasks or subtasks at a subordinate unit or individual level.

The Brinkley and Wrockloff report illustrated a very parsimonious analysis of missions and tasks at the large unit level. The two missions defined above may be considered to be large classes or sets of missions, each of which would include a longer list of subordinate missions. The relatively short task list, (five tasks), in the case of CCH, followed immediately upon mission definition without an intermediate level of analysis and limited the usual geometric growth of the analytic work at lower levels.

TABLE 6. Analysis of CCH With Respect to Battlefield Functions and Tasks (From USA Armor Center, 1980).

FUNCTIONS	TRADOC Battlefield Tasks								
	TARGET SERVICING	COUNTER FIRE	AIR DEFENSE	BATTLE SUPPORT	COMMAND, CONTROL AND COMMUNICATIONS	INTELLIGENCE, SURVEILLANCE AND TARGET ACQUISITION	INTERDICTION	FORCE MOBILITY/COUNTERMObILITY/SURVIVABILITY	RECONSTITUTION
ENGAGE TARGETS	X								
OBTAIN INFORMATION/COMMUNICATE					X				
CONDUCT MOBILE OPERATIONS								X	
CONDUCT CONTINUOUS OPERATIONS				X	X				X
CONDUCT OPERATIONS UNDER ALL NBC CONDITIONS	X			X	X			X	X
CONDUCT OPERATIONS ALL VISIBILITY/CLIMATES	X			X	X			X	X
MAINTAIN HIGH DEGREE OF MATERIEL READINESS				X				X	X
SURVIVE ENEMY ATTACKS								X	X

The Critical Collective Task Concept

The "critical collective task" is another problematic concept. Typically, the US Army literature defined two criteria for selection of tasks for training, linking selection to (1) necessity for mission accomplishment, and (2) necessity for unit survival. Those tasks selected for training upon consideration of the two criteria were identified as critical tasks. While unit training and evaluation development are indicated as the prime purposes for collective task analysis, it is apparent from the survey results and literature review that other purposes, such as "Allocation of job functions to operators," or "Development of unit training devices," are also occasionally addressed. For example, in the Brinkley and Wrockloff paper, the critical tasks were identified for yet another purpose — the identification of advanced concept doctrine and equipment deficiencies, and, only secondarily, training needs.

In the US Navy and US Air Force literature, task analysis and criticality determination were often found to be part of training device development, usually at the individual or crew (unit) level (Folley, 1964; Cream et al., 1978). Cream recommended a combination of ratings of criticality with ratings of frequency of performance and difficulty of performance (C/F/D) as indices of importance for training device decisions. The implication was that a task would be likely to be selected for use on the device if it is rated high on one or more of these dimensions. C/F/D priorities were intended to assist the developers and users in determining fidelity requirements and, in conjunction with costs and funding, in the final determination of tasks to be included in the training device repertoire. The criteria for criticality were not predetermined, but follow-up questions were used to explore each subject matter expert's reasons for ratings given on each of the three dimensions.

In the development of crew coordination training Cream recommended the collection of data, including C/F/D analyses, from crews judged to be proficient in crew coordination. His approach could be identified as a critical incident technique in that specific attention was ". . . directed at those aspects of a mission that cause or are likely to cause problems of coordination."

US Army researchers also identified crew coordination tasks in their aircrew operational requirements analysis for helicopter nap-of-the-earth (NOE) flight. (Gainer and Sullivan, 1976.) They also used a variation of critical incident technique in the special analysis of performance requirements associated with the detection, diagnosis, and response to emergencies and contingencies in NOE flight. These might have been regarded as super-critical tasks or subtasks in that they were responses to emergencies — critical events — and were included within a larger set of tasks already derived from functions regarded as essential to successful performance of a mission segment.

They determined criticality of task performance from ratings as to (1) whether or not successful performance is vital to the primary mission objective, and (2) whether or not the task must be performed at a precisely constrained moment or sequence in time.

This approach is interesting, by comparison, for its elimination of survival value as a criterion of criticality, a criterion which must be closely correlated with mission success in most cases. It is also interesting for its inclusion of time constraints and, by inference, special contingencies and emergencies, in considerations of criticality.

Complex Tasks and Step Sequences

In the ARI research on aircrew requirements for nap-of-the-earth flight it was recognized that procedures in crew coordination skills, even the crew work load in crew coordination tasks, are not easily specified. The authors said,

"We do not know what might be done to improve or facilitate the development of crew coordination skills. In other areas of human performance where teamwork is a central requirement, the best training method has been to clearly delineate the workload distribution, define the task procedures "by the numbers," then practice and drill. This may be the best approach in NOE training as well. But the task allocations in NOE operations are not that cut and dried; a good deal of impromptu task sharing necessarily takes place; so drill alone will not suffice. Improvements in crew coordination training can best be developed from a better understanding of NOE crew workload than now exists. At present, not even an acceptable method of defining or measuring workload has been developed. Recommendations in this area cannot be made without further research." (Gainer and Sullivan, 1976.)

It appears that with experience together, crewmembers learn each other's operating characteristics and (often unspoken) needs so that each one can anticipate his partner's actions or intentions. "Impromptu task sharing" is not easily represented in a task-subtask-step hierarchy and step sequence.

US Air Force researchers recognized a similar problem in their approach to crew task analysis for the purpose of training device development.

"The data acquisition process . . . assumes that all tasks can and should be reduced into more detailed sub-tasks and that tasks can be described in fixed sequences of discrete steps. The application of these assumptions may not be clear for some highly complex skills. Some tasks are not easily reduced into a hierarchical set of sub-tasks. In such cases, the task analysis may have to be terminated at a relatively global level so that the nature of the task is not distorted. This termination could result in a vague description of simulator requirements and reduced capability for precise performance measurement. It then becomes important to ensure that the personnel involved in design and fabrication of the training device either have experience with the equipment or have direct access to personnel who are experienced. In addition, experienced personnel should continually validate the adequacy of the factors that have not been specified (e.g., display characteristics, control "feel," scenario integration, and other general issues of fidelity)." (Cream et al., 1978.)

Klein explored this problem in a series of papers (Klein, 1977, 1978, 1980) in which a more intuitive approach was recommended for the comprehension and description of high proficiency complex human performances. This approach was suggested as a supplement to the procedural skills approach, when dealing with performances which require not only the skills but the ability to recognize the context in which to apply the skills. These are high proficiency behaviors involving the perceptual recognition of an ambiguous new situation as similar to those situations already understood. Klein asserted that some aspects of highly skilled performance cannot be described in procedural steps; e.g., recognitional capacity, which depends upon training and experience, cannot be described in steps to be followed. He offered examples of such tasks requiring complex recognitional capacity as: "making a decision, catching a ball, maneuvering against an opponent." (Klein, 1979.) In guidelines for the use of user guides he quoted (from Montemerlo and Harris, 1978) a facetious example of procedures to be followed in painting a masterpiece: "(1) Think of a great idea; (2) Sketch it out; (3) Fill in the colors and details; (4) Check it over and make any necessary alterations." The collective analyst who compares these directions to the procedural guidance for task analysis may find it less amusing.

In a more recent paper, Klein recommended a comparison-guided model for the analysis of a complex task, such as decision making. (Klein, 1980.) In this model the skilled decision maker is regarded as beginning with an understanding of the overall situation. He may then recognize how the situation is like others he has studied or experienced and how it is different from many. In recognizing these similarities and differences he may identify aspects of the current situation which are consistent with the judgments of similarities and differences. He is then ready to use his past learning to suggest courses of action and probable consequences for the current situation. Klein described this as a top-down model in that it begins with an overall comprehension of the situation and a recognition of similarities and differences. Then it proceeds with a differentiation of elements which are meaningful only in the context of comparisons. This results in comparisons of options and consequences which facilitate the decision.

Quality Control in Collective Task Analysis

The term quality control is used here to denote a validation of interim (not final) processes and products of analysis of collective tasks. The term may include the contributions of subject matter experts who are consulted to assure content accuracy and comprehensiveness. The term usually excludes internal reviews by the analyst team, which are intended to assure consistency and coherence. Quality control is regarded as a validation function and almost all writers included some such effort involving an external review. The principal analyst was thought to need SMEs, especially in the early phases of analysis, to check mission and task lists and to assist in the evaluation of tasks for training or other purposes. SMEs were also found useful, later in the analysis, for verifying task lists and task statements or training objectives. Rules or procedures for SME reviews are not found in the reports which mention them. (O'Brien et al., 1975; Gainer and Sullivan, 1976; Blau et al., 1980; TRADOC, 1981.)

A more formal quality assurance process is the Board Review, specified in TRADOC guidance. This was recommended to check (1) missions lists and missions criticality, (2) function and task analysis, and (3) task scales and standards, in the Battelle paper. While the format was not dictated, it was clearly indicated that forms and instructions would be prepared in order to record the Board's decisions in an objective manner. TP 310-8 also called for one (and only one) Board Review focussed on the critical and non-critical mission and task list. This was a drastic reduction from the earlier draft TP which called for numerous Board Reviews throughout the analysis process. The ARI aircrew training requirements analysis also used a formal quality check in addition to SME consultations. This was not a Board Review, but a review by four operational aviation units who were requested to verify (for accuracy and relevance) the lists of training objectives and the task analysis data.

These quality control checks are undoubtedly important and necessary, in such a complex process, involving many judgments. Some elementary questions about quality control can be asked:

- (1) Why is the quality check done?
- (2) Who can best do it?
- (3) How is it best done?
- (4) When (at what points in the analytic process) must it be done?

Consideration of these questions indicate that both the users and the analysts can make important contributions to quality control actions. Needs of the user are primary determinants of the purposes and limits of the analysis task. Quality can be affected by the selection of well qualified SMEs and also well qualified representatives of approving authorities. Reliability and validity can be enhanced by using well-defined procedures and by objective recording of review results. Quality checks must be made at as few points as possible -- the critical points which most affect the analysis process and product.

These reviews may occur early in the process, to validate mission analysis and agree upon criteria for criticality or selection of tasks for training. Reviews at later points may include the selection of critical tasks and task dimensions and standards. This suggests a minimum of from two to four reviews for quality control prior to completion of the analysis.

Training for Collective Analysts

Discussions with analysts and survey results indicate that there is currently no training available for beginning collective analysts. All survey respondents indicated reliance on on-the-job experience and many were able to get little or no guidance from their supervisors. This was not surprising since most of the supervisors of collective analysis activities indicated that they, themselves, had no training in the field. About half the working analysts had had short courses in individual instructional development. The five centers which responded to the survey question on man days effort on procedures

development estimated from 90 to 300 man days per year were expended on procedures ($\bar{x} = 125$). This was about one-third of the total effort in collective task analysis within each organization. Some questions were raised about the necessity for repetition of procedures development activities, but the variety of collective analysis purposes indicated and observations on rotation of military and civilian analyst personnel raise the likelihood of repeated learning and development for collective analysis personnel.

A conservative conclusion from the observations above would suggest that the military services would benefit substantially and save costs by providing collective analysis training for instructional development personnel. However, such training would only be cost effective if based upon an acceptable methodology -- that is, a simple and useful methodology, adaptable to different purposes.

SECTION V. Discussion and Conclusions

Terminology and Concepts

Modrick and Wingerl described the failure to connect task analysis and psychological theory to system design. Their diagnosis of the failure identified two broad deficiencies in task analysis:

- (1) inconsistencies in terminology.
- (2) lack of objectives or goals for the analysis (Modrick & Wingert, 1978).

Their diagnosis certainly applies to the analysis of collective tasks. There is no consistency in terminology, and purposes are either not stated or very general and inclusive in most references. There is not yet sufficient agreement on even the most basic terms to get reliable results in analysis. Basic concepts, such as unit, mission, collective task and critical collective task are not clear and are very confusing when combined in propositions. (See the Annotated Terminology (Appendix A) for definitions of these terms and further notes.) For example, the "mission" of an air crew (Gainer and Sullivan, 1976) and the "mission" of a tank platoon (Drucker and O'Brien, 1981) are probably better designated as collective tasks or as crew task and platoon task. It is unlikely that any current method of collective analysis is effectively applied at the unit level of a crew. It is not certain that the concept of mission is applicable below the unit level of the company or (cavalry) troop. Modrick and Wingert point out that the term "task analysis" is used to denote both a method and a final product. The method usually implied is the reduction (or "decomposition") of tasks into step-by-step descriptions of the behaviors, along with an identification of environmental (and organizational) conditions, cues and standards. The resulting task statements and training objectives are the products. When the task analysis product is delivered, it may be any one of these -- the training objectives, the task statements, the whole audit file, or even an interim product such as the task list.

A further problem lies in the relationship between collective task analysis and mission-task analysis or collective front-end analysis. In the words of Modrick and Wingert,

"Finally, there is a relatively new jargonistic term, "Front End Analysis." It encompasses all of the above (varieties of task analysis), more or less. There is no apparent technical need for the term and it contains no new methodology. This may be a renaming of the wheel rather than a reinvention."
(Modrick and Wingert, 1978.)

Analysis Objectives, Results and User Participation

Though task analysts are aware of the uses to which their products will be put, there is sometimes little effort to determine that their products provide useful information in a format convenient to the user. Development of new training and development of evaluation instruments for units were the

prevailing purposes of collective task analysis indicated in the brief survey. The focal units were the battalion (squadron) and its subordinate units. When asked about the purposes of their analysis, some respondents answered that they were not concerned about its use. This was puzzling in the context of an analysis which has its only value in its applications. To return to the assessment of Modrick and Wingert:

"The lack of objectives is a failure to integrate the use of the task data into methods of data gathering and analysis. The uses should provide requirements and constraints that identify or define the data needed and the processing necessary to produce the required output. In the absence of these objectives we tend to err in the direction of gathering or generating too much data;" (ibid.)

With reference to Axiom 1 and its corollaries it is apparent that such user requirements and constraints will affect not only the kind and quantity of products, but the procedures in the task analysis, itself. If Modrick and Wingert are right about the direction of error (above) this may be an instance in which coordination with another agency promotes efficiency.

The user is being consulted through the use of SMEs (in 4 of 5 Army methods reviewed above). However, a way of bringing the user into the process and product even more would be to include user personnel on the review boards at key points in the process. (The user personnel might include representatives of the training developer as well as representatives of the training units in the case of a training oriented analysis of collective tasks.) Thus quality assurance procedures could assure utility and convenience to the user and help to prevent the production of useless, extraneous information.

General Principles in Analysis of Collective Tasks

Analysis of collective tasks of a given unit is contingent upon a mission analysis of that unit. Therefore it is done as a part of a mission/task analysis or following upon a mission analysis. (In this sense it is a top-down process as indicated in Assumptions 1 and 2 above.) The completion of an analysis of collective tasks, depending somewhat upon its objectives, may result in a set of task statements or training objectives, each one specifying the task, cues, conditions and standards of performance of the task. The set of task statements may be made up of several subsets, each corresponding to a specific echelon or sub-unit.

A collective task is a unit action, performed by certain identified units, having a beginning and an end and definable products or outcomes. It is defined by the unit to which it is assigned, the action and accomplishment, the condition(s) within which it is performed, the cues precipitating performance and the performance standard for successful accomplishment. The collective tasks assigned to a unit (echelon) should be appropriate to that echelon. The idea of defining a task in terms of activities, a time period, cues, conditions and standards is much like the concept of an individual task. What is different about collective task analysis is that the collective task must be identified

as a unit activity. (See Axiom 1 above.) This presents a certain complexity because a large organization, such as a battalion, is made up of sub-units and echelons, e.g., command post, headquarters support units, companies, platoons and crews, and the tasks and subtasks of these subordinate units are among the integral activities of the large organization.

One way to resolve this complexity is to use two concepts suggested in the literature. First, the concept of generic functions will include a number of activities which occur across many units (e.g. command, control and communications (C³)). Second, the concept of dual identification of tasks will clarify the situation in which a function or collective subtask of a supra-ordinate unit is also a collective task for a subordinate unit (e.g. the generic battalion function, C³, is also the task of the battalion command post; the battalion subtask, maintenance, is also the task of the maintenance platoon (in Operational and Organizational Concept, Division 86 Tank Battalion, USA Armor Center and Ft. Knox, 1980)).

These two concepts, the concept of generic functions and the concept of dual identification, permit the allocation of more comprehensive task "chunks" to the higher level organizations. The resolution of the supraordinate tasks into their detailed parts can be done at a lower (subordinate echelon) level in the analysis process. The number of levels of analysis (e.g. between mission and task) can be reduced and the number of tasks per echelon can be limited.

The reduction of levels of analysis and number of tasks per echelon simplifies the collective analysis process. This, along with the clarification of analysis objectives and the increased participation of user representations in quality control will contribute to the utility, relevance and simplicity ranked high among methodological criteria by respondents to the survey.

Finally, what are the characteristics of a complete analysis of collective tasks? The following are suggested by the current state of the art as characteristics or components of a thorough analysis of collective tasks:

- (1) mission-related;
- (2) includes an analysis management plan and a statement of purposes, including intended uses of the products;
- (3) includes an audit file of analysis records;
- (4) consultation with SMEs to verify task lists, task conditions and standards;
- (5) quality controls, including timely user reviews of --
 - (a) mission analysis,
 - (b) criteria for criticality or selection of tasks,

- (c) critical task selections,
- (d) task dimensions and standards;
- (6) (referenced) definitions of key terms.

REFERENCES

- Blau, T. H., Kaufman, R., and Morgan, R. M. The integration of collective and individual front-end analysis. Work performed by Battelle Laboratories for US Army Training Board, Ft. Eustis, VA, Feb 1980.
- Brinkley, W. A. and Wrockloff, G. E. III. Mission area analysis: Close combat (Heavy) (U) (SECRET). US Army Armor Center, Ft. Knox, KY, Jun 1980.
- Cream, B. W. A functional integrated systems trainer for individual and crew coordination training. Proceedings of the 4th Annual Symposium on Psychology in the Air Force, 1974.
- Cream, B. W., Eggemeier, F. T., and Klein, G. A. A strategy for the development of training devices. US Air Force Human Resources Laboratory, Brooks Air Force Base, TX, Aug 1978.
- Drucker, E. H. and O'Brien, R. E. Mission-based analyses of armor training requirements (Draft) (7 volumes). US Army Research Institute for the Behavioral and Social Sciences, Feb 1981.
- Folley, J. D., Jr. Development of an improved method of task analysis and beginnings of a theory of training. Technical Report, Applied Sciences Associates, Valencia, PA, Jun 1964.
- Gainer, C. A. and Sullivan, D. J. Aircrew training requirements for nap-of-the-earth flight. Research Report 1190, US Army Research Institute for the Behavioral and Social Sciences, Washington, DC, Aug 1976.
- Headquarters, Department of the Army. Dictionary of United States Army Terms. Army Regulation 310-25, Washington, DC, Sep 1975.
- Headquarters, Ft. Monroe. Division 86 Blueprint of the Battlefield. Ft. Monroe, VA, Apr 1979.
- Headquarters, US Army Training and Doctrine Command (TRADOC). Operational concept heavy division operations 1986, TRADOC Pamphlet 525-4, Ft. Monroe, VA, Dec 1980.
- Human Resources Research Office. Use of job and task analysis in training. Professional Paper 1-69. Presentations at Headquarters, US Continental Army Command, Fort Monroe, VA, Jan 1969.
- Klein, G. A. Automated aids for the proficient decision maker. Klein Associates, Yellow Springs, OH, 1980.
- Klein, G. A. Phenomenological approach to training. Technical Report 77-42, Advanced Systems Division, US Air Force Human Resources Laboratory, Brooks Air Force Base, TX 78235, 1977.

- Klein, G. A. User guides: Some Theoretical Guidelines for their use. Research Report prepared by Klein Associates, Yellow Springs, OH 45387, for the US Air Force Office of Scientific Research, Bolling Air Force Base, DC, 20332, Oct 1979.
- Modrick, J. A. and Wingert, J. W. The misconnection between task analysis and psychological theory. Paper presented at the American Psychological Association Convention, Toronto, Ontario, Sep 1978.
- Montemerlo, M. D. and Harris, W. A. Angels, pinheads and task analysis. Paper presented at the American Psychological Association Convention, Toronto, Ontario, Sep 1978.
- O'Brien, R. E., Kraemer, R. E., and Haggard, D. F. Procedures for the derivation of mission-relevant unit task statements. Technical Report 75-4, Human Resources Research Organization, Alexandria, VA 22314, May 1975.
- Silverman, J. A computer technique for clustering tasks. Technical Bulletin STB 66-23, US Naval Personnel Research Activity, San Diego, CA 92152, Apr 1966.
- Softech, Inc. An introduction to SADT structured analysis and design technique, Softech, Inc. Waltham, MA 02154, Feb 1976.
- Softech, Inc. Overview description of the new Army training and testing system. Softech, Inc., Waltham, MA 02154, Jul 1976.
- Softech, Inc. The role of training in providing the combat-ready tank system. Softech, Inc., Waltham, MA 02154, Oct 1976.
- Softech, Inc. SADT, Structured analysis and design technique reader course. Softech, Inc., Waltham, MA 02154, 1976.
- US Army Armor Center (USAARMC). Collective Analysis Standing Operating Procedures (SOP), (Draft), USAARMC, Directorate of Training Developments, Ft. Knox, KY, Nov 1980.
- US Army Armor Center, Training development handbook. Phase I: Analysis. Instructional systems development procedures. US Army Armor Center, Ft. Knox, KY, Apr 1978.
- US Army Training and Doctrine Command (TRADOC). Collective front-end analysis for development of the Army training and evaluation program (ARTEP) and a method for the development of drills, TRADOC Pamphlet 310-8, 25 Sep 1981.
- US Army Training and Doctrine Command (TRADOC). Development, preparation and management of Army training and evaluation program (ARTEP). TRADOC Reg 310-2, Ft. Monroe, VA 23651, 1976, Revised 10 Dec 1979.

US Army Training and Doctrine Command (TRADOC), Individual/Collective Training and Development Glossary. TRADOC Circular 350-3, Ft. Monroe, VA, Dec 1979.

US Army Training and Doctrine Command (TRADOC). Interservice Procedures for Instructional Systems Development. TRADOC Pamphlet 350-30, Ft. Monroe, VA 23651, 1975.

US Army Training and Doctrine Command (TRADOC). Job and task analysis handbook. TRADOC Pamphlet 351-4(T), Ft. Monroe, VA 23651, 1979.

US Department of Labor. Handbook of occupational key words. US Dept. of Labor. Manpower Administration, Washington, DC, 1975.

APPENDIX A

ANNOTATED TERMINOLOGY FOR ANALYSIS OF COLLECTIVE TASKS

In the following list of terms and definitions, italics indicate a definition preferred by the author for the purposes of this review. Comments or definitions not followed by a reference citation are those of the author.

ACTION (Element of a Task) --- ". . . describes in observable and measurable terms the specific behavior a unit is expected to perform." (O'Brien et al., 1975.)

ACTIVITY CATEGORY -- ". . . a major subject or operational area, e.g., Defense, Reconnaissance, Support and Communication." (USAARMC, DTD, 1980.) This term is used to refer to a class of missions or mission statements.

ANALYSIS -- The systematic, procedural determination of the activities and accomplishments required of an individual or organization in the execution of its job(s) or mission(s). The process/methodology of job/task analysis which identifies and determines tasks, cues, conditions and standards. (See also ANALYSIS, TC 350-3.)

ANALYSIS OF COLLECTIVE TASKS -- *The systematic procedural determination of the unit activities and accomplishments, including the relationships among tasks, actions, conditions and standards, required of a unit in the execution of its mission(s)*

ANALYSIS OF INDIVIDUAL TASKS -- The systematic, procedural determination of the activities and accomplishments required of an individual (soldier) in the performance of his job. This includes the identification of critical tasks of associated actions, conditions and standards.

AUDIT FILE -- "The audit file is the location, container or collection of materials accumulated during the CFEA. The file contains a total history of all events connected with the CFEA, to include decisions made and justifications. It must be set up so as to make all the contents easy to find." (TP 310-8.)

AUDIT TRAIL -- "A methodical list of events, rationale, data sources and justification for changes from the original plan/concept; alternate courses of actions are delineated/filed in chronological sequence. The audit trail should accompany the audit file." (TP 310-8; see also TC 350-3.)

COLLECTIVE FRONT-END ANALYSIS (CFEA) -- (mission/task analysis) -- "The process of analysis whereby the TOE capability of a unit, the unit missions (stated and implied), the most current tactical doctrine and applicable threat doctrine that are available are systematically analyzed and integrated to determine a unit's critical missions and critical tasks. (TP 310-8; see also FRONT-END ANALYSIS in TC 350-3.)

COLLECTIVE TASK -- *A specific unit action and accomplishment required in the execution of a unit mission. A collective task is a relatively discrete process with an identifiable starting and ending point. A specific collective task is defined by the unit to which it is assigned, the action (and accomplishment or objective result), the condition, i.e., the organizational and physical environment plus the threat, and the performance standard (criterion or criteria) for acceptable accomplishment. A collective task assigned to one unit may be decomposed into phases or parts, including subtasks which may be performed by that same unit or a subordinate or supporting unit. If the subtask is performed by a subordinate unit it may be appropriately called a unit task for that (lower) unit. A subtask may be an individual task.*

"a. A unit of work requiring more than one individual for its completion (e.g., replacement of an equipment/system component that is too heavy/cumbersome for one individual to replace; use of a weapon system too complex for one individual to operate/manipulate).

b. A unit of work that must be accomplished by a whole echelon (e.g., platoon, company, battalion). This can be a mission requirement (e.g., secure bridgehead) which is then further refined through subunits and broken down into individual tasks.

c. These tasks have an identifiable start and end point and result in a measurable accomplishment or product.

d. Subtasks or elements of a collective task may be individual tasks in their own right." (TP 310-8; see also TC 350-3.)

TC 350-3 included in the definition, "These tasks are level-of-involvement dependent." Otherwise the TP 310-8 definition is almost identical with that in TC 350-3. It is questionable whether subtasks assigned to the platoon or crew level should be called collective tasks. It may be more consistent to keep collective tasks at the company or higher level and designate collective subtasks which are performed by the platoon or crew as unit tasks, platoon tasks, crew tasks or individual tasks. This would tie collective tasks to missions at the company or higher echelon level.

CONDITION (element of a task) -- ". . . presents the essential and definitive factors that limit or facilitate execution of a given task behavior by a unit." (O'Brien et al., 1975.)

"The situation/environment in which the soldier/unit will be expected to accomplish a task." (TC 350-3.)

"The situation/environment in which the soldier/unit will be expected to accomplish a task under combat conditions. Conditions include any pertinent factors that influence task performance, including some or all of the following: location of performance, environment, equipment, manuals, or supervision required." (TP 310-8.)

In HumRRO's 1975 approach, the descriptors were primarily in terms of organizational context. In Drucker and O'Brien (1981) the mission, enemy threat, terrain/weather and troops available (METT) were included in conditions (for leadership tasks only). This more comprehensive usage appears to be more consistent with the definition above and others available.

CRITICAL MISSION -- In TC 350-3 and in TP 310-8 there is confusion of criticality criteria for tasks with criticality criteria for missions. Critical missions/tasks (are defined as) . . . "Collective missions/tasks identified by front-end analysis (mission/task analysis) that provide an immediate, direct, or significant contribution to the ability of a unit to perform a specific combat mission/task or to survive on the battlefield." (TP 310-8.)

While one can conceivably use contribution toward unit mission success and contribution toward unit survival as criticality criteria for a task, it is a very circular logic to define contribution toward unit mission success as a criticality criterion for a mission. It may be useful to consider whether successful performance of a mission contributes significantly to unit survival. Other criticality criteria can be considered. A mission may be judged to be critical if it is a primary and unique unit mission. Since a mission may be performed by the unit as a part of a larger overriding mission of the higher level organizations, then, if that unit mission is also unique (i.e., a mission for which the unit is singularly equipped and trained), the mission can be regarded as critical.

A mission may also be regarded as critical if it is most representative of a class of missions to which the unit is dedicated. Since not all possible missions can be trained only those which are most representative of the class of missions are likely to be trained.

Representativeness may be determined by an analysis of task commonality in a mission-task-situation comparison across missions within a class and across mission classes. Such analysis could provide insight into which missions and which task-situations should receive emphasis in training. This is analogous to the frequency (F) concept in USAF C/F/D analysis.

With regard to ARTEP inclusion it is important to note that the criticality of the mission is not determined by ARTEP inclusion, but that ARTEP inclusion may be determined by criticality (of the mission or task). (See also critical missions/tasks in TC 350-3.)

CRITICAL COLLECTIVE TASK(S) -- *Those tasks determined to be essential (e.g. for training if training development is the purpose) in a review procedure using criticality criteria. Previously accepted criteria are (1) essential to mission success and (2) essential to unit survival. Refinement of these criteria or additional criteria may be needed for analysis of collective tasks.*

"A task selected for training by a task selection board in a service school and approved by the school's commandant. It must be a task which is essential to accomplish the unit's mission and/or survive." (TP 310-8.)

The latter definition is somewhat circular and does not appear to be very helpful to the analyst who must make some recommendations regarding criticality to a Review Board or Commander. Nor does it help the Review Board or Commander in making the judgments. The final product of the criticality review is such a set of tasks selected (for training or other planning purposes).

CUE -- "Word, situation or other signal for action. An initiating cue is a signal to begin performing a task. An internal cue is a signal to go from one element of a task to another. A terminating cue indicates task completion." (TC 350-3.)

DUTY -- ". . . a functional area that the system or one of its subsystems must accomplish to ensure that the major mission operation (MMO) is accomplished." (O'Brien et al., 1975.)

MMO are divided into duties. A duty is the largest unit of action which may be designated as a task in the HumRRO (1975) method. If it is complex or made up of many parts it is likely to be simply designated duty and broken down into smaller tasks and subtasks. (See also DUTY, AR 310-25, and DUTY ASSIGNMENT and DUTY POSITION TASK in TC 350-3.)

ECHELON(S) -- *"recognized portions of a unit, such as companies, troops, batteries, platoons, squads, sections, teams and crews."* (TP 310-8.) Usually refers to one of series of levels in an organization. (See also ELEMENT in this list, and see AR 310-25.)

ELEMENT(S) -- ". . . the staff or operational organization(s) which form the principal structure of, and are immediately subordinate to the next larger organization (e.g., Ground Cavalry Troop is an element of the Divisional Cavalry Squadron)." (USAARMC, DTD, 1980.)

The term element is used synonymously with echelon to denote a subordinate unit (in relation to a larger organization). However, echelon is given a more comprehensive usage with reference to supraordinate units, as well.

Element is also used to denote a part of a task definition, e.g., the standard element of a task, and the action element of a task. (See AR 310-25.)

FRONT-END ANALYSIS -- (In collective mission/task analysis) "The process of analysis whereby the TOE capability of a unit, the unit missions (stated and implied), the most current tactical doctrine and applicable threat doctrine that are available are systematically analyzed and integrated to determine a unit's critical missions and critical tasks." (TP 310-8; see also TC 350-3.)

FUNCTION -- *A pervasive and recurring activity which is essential to the execution of several missions and many or all collective tasks. A function at the supraordinate level may recur as a task or subtask at lower echelon levels of analysis. Thus, a function may correspond to a subtask or a major component activity in a crew, small team or special section task. Examples of functions are: (1) Command and Control (C²), and Communication, which are the special tasks of the division tactical command post and the division main command post as acting for the commander; (2) Target Engagement, which is essential to the collective tasks, Interdiction and Counter-fire, and which is a crew task for artillery or air defense missile crews.*

The Battelle Laboratory's paper uses the term function in two different ways. One meaning is in reference to the blocks in the flow diagram of the analysis process. Each block is called a function. Another meaning is " . . . an aggregation of results which decompose into several tasks but which are smaller in size than mission. A function is not a collective task. A sum (group) of tasks makes up a function; a group of functions makes up a mission." (Blau et al., 1980.) This last definition is opposed to the definition recommended above (*italics*).

INDIVIDUAL TASK(S) -- "a unit of work requiring only one individual for its completion. The task has an identifiable start and end point and results in a measurable accomplishment or product." (TP 310-8.)

Individual tasks are usually done with coordination and support from others, so they are not entirely independent, but, given minimum situational support, an individual task is executed by one person.

INDIVIDUAL/COLLECTIVE INTEGRATION -- "The process of blending the specified and implied individual tasks, leader tasks, and collective tasks/missions in order to maximize the cohesion of individual/collective training. The integration process shows the relationship between individual tasks and collective training tasks/missions. Also, it illustrates the relationship among the individual tasks, collective subtasks, and leader tasks. The process reveals the existence of individual training dependencies and provides the trainer with a diagnostic measure to identify weaknesses needing corrective training. By listing leader tasks, the integration process assists in the planning and conduct of multi-echelon training." (TP 310-8.) (See INDIVIDUAL/COLLECTIVE INTEGRATION MATRIX in TC 350-3.)

The definition above does not clarify the process for the analyst. It probably overstates the benefits derived from individual/collective task integration. The process usually involves a cross-check matrix which displays those individual tasks judged to be in support of the accomplishment of a collective mission or task.

MISSION(S) -- *an activity and a goal assigned to a unit by higher command and initiated at a specified time. The mission ". . . usually contains the elements of who, what, where, when and the reason therefor, but seldom specifies how."* (FM 101-5-1.) *The kinds or classes of missions expected are stated explicitly or implied by the TO&E for the unit. If the unit exists only as a developing concept and no TO&E is available, the O & O Concept and/or the threat analysis can be used as the basis for development of the classes of missions expected to be assigned to the unit.*

"Missions are major TOE activities performed by recognized TOE echelons. Missions may be assigned and/or implied by either the TOE or a major command (MACOM) to support local contingencies." (TP 310-8.)

ARI defined missions ". . . as specific goals which were assigned to a unit . . ." and ascribed the mission to the next higher echelon (above the unit under analysis) leaving the brunt of analysis at the level of mission phases (Drucker and O'Brien, 1981). HumRRO used major mission operations (MMO) as the next lower level of analysis (O'Brien et al., 1975).

USAARMC, DTD (1980) defined a unit mission as a mission performed by one of the unit elements.

This last definition seems to omit the primary mission of the focal unit. It does not clarify the distinction between mission and task. It may be advantageous to reserve the term, mission, for units which operate ordinarily as a whole, and, in tactical units, reserve the term, mission, for units which are given tactical assignments (e.g. company or platoon or the lowest echelon). The term, collective task could be reserved at the same level (with mission) and lower level units would be assigned not missions but platoon tasks or subtasks and crew tasks.

MISSION ANALYSIS -- the development of echelon-mission-condition combinations representing the important classes of missions derived from the TO&E and implied by the unit operational concepts. Since all of the echelon-mission-condition combinations cannot be explored in detail it will be advantageous to define the most representative (of classes) or common combinations for a unit along with the ranges of conditions. ". . . includes identifying those actions (major mission operations) which a system is expected to do. MMOs are derived from general missions which have already been derived from the TOE missions." (O'Brien et al., 1975.)

MISSION PHASE -- ". . . cluster(s) of activities that normally occur during the performance of . . . mission(s)." (Drucker and O'Brien, 1981.)

In the ARI approach -- "Mission phases are divided into two types: (1) tactical and (2) supporting mission phases. Each mission phase includes a cluster of unit operations which may be considered as team operations."

". . . the mission phases identified during the project (Drucker and O'Brien, 1981) were as follows:

1. Offense
2. Defense
3. Occupy Assembly Areas
4. Plan Operations
5. Conduct Movement
6. Sustaining Operations."

MISSION STATEMENT -- the required unit actions, duties and accomplishments, as stated in the TOE, plus implied or supporting actions.

USAARMS organized each unit mission on a bar chart defining the higher echelon unit mission in terms of the activity categories and specific activities required of subordinate echelons within the unit.

MAJOR MISSION OPERATION (MMO) -- ". . . the major functional area within a system's TOE and general missions." (O'Brien et al., 1975.)

(Identified as a unit job.) An MMO is the same as a mission phase (Drucker and O'Brien, 1981) with reference to support operations analysis, but an MMO may be equivalent to a team operation in tactical operations.

MAJOR MISSION OPERATIONS as identified by O'Brien, et al.,

Tactical	Supporting
<ul style="list-style-type: none"> . Security MMOs . Offensive MMOs . Defensive MMOs . Retrograde MMOs 	<ul style="list-style-type: none"> . Occupy Assembly Areas . Plan Operations . Conduct Tactical Road March . Conduct Sustaining Operations

METHODOLOGY (for ANALYSIS OF COLLECTIVE TASKS) -- *The terminology, assumptions, and basic propositions, i.e., the concepts and principles of collective task analysis procedural development.*

OPERATION -- *a collection of related tasks and functions which can be broken down into several tasks. An operation may correspond to a mission phase or a major mission operation. The term operation may be reserved for those collections of related tasks into which a mission is decomposed in the first analysis. Operations are routinely classified as tactical or supporting operations. The tasks making up an operation may be related in the sense of contiguous in time, similar in purpose and like in classification (tactical or supporting) above. Examples of OPERATIONS are: (1) Equipment maintenance; (2) Air defense; and (3) Combat support.*

Team operations are ". . . clusters of activities performed by a tank team during the conduct of a mission. Once the mission phases were identified, the next step in the analysis was to identify the team operations performed during each mission phase." Tactical team operations (Drucker and O'Brien, 1981) are equivalent to major mission operations (in O'Brien et al., 1975).

Team Operations Performed by Mission Phase

(Drucker and O'Brien, 1981)

Mission Phase		
Offense	Defense	Supporting
Movement to Contact	Occupy Battle Position	Occupy Assembly Area
Hasty Attack	Defend Battle Position	
Bypass	Holding	Plan Operations
Holding	Withdraw	
Deliberate Attack	Delay	
Exploitation and Pursuit	Counterattack	Conduct Movement
		Sustaining Operations

PERFORMANCE STANDARD(S) -- *the criteria for acceptable accomplishment of a task; these make up an important part of the performance objective. Criteria can be process and/or product oriented and may use different dimensions or aspects for observation and measurement. (See STANDARD.)*

PLATOON TASK -- *a part of a company or troop collective task which is assigned to a platoon for accomplishment at a specified time. The platoon task may be a unit subtask at the company or higher level.*

PROCEDURE (for analysis of collective tasks) -- the specific sequence of actions required in accomplishment of an analysis of collective tasks for a stated purpose and a given unit.

SPECIAL ELEMENTS -- ". . . sub-unit(s) not listed in the organizational diagram of the TOE, but designated by doctrine (e.g., Squadron Control Assessment Team and Troop Rescue Squad)." (USAARMC, DTD, 1980.)

STANDARD (element of a task) -- ". . . specifies the criterion or level of performance that must be met by a unit to demonstrate successful execution of a given task behavior. The two most commonly used criteria of performance are accuracy and speed." (O'Brien et al., 1975.)

"Standards generally describe performance in terms of sequence, completeness, accuracy and time." (USAARMS, DTD, 1980.) In addition, number of errors (in process) and (with reference to a product standard) tolerances, rate of production and quality (reciprocal of rate of rejects or defects) may be considered. "Standards for performance of a task can be established by defining an acceptable product or acceptable process, or both."

"Product standards are best when:

- . The product is observable and can be inspected.
- . The process by which the product is produced cannot be easily observed.
- . The process of performance is relatively unimportant in comparison to the product.

Examples of tasks well suited to product standards are:

- . Prepare a tactical operations plan.
- . Collect data for classification of a bridge.
- . Plan direct fires.

Process standards are best when:

- . Performance of the task does not produce a readily observable product.
- . Failure to use the correct process could result in damage to equipment, danger to personnel, mission failure, or project delay.

Examples of tasks well suited to process standards are:

- . Provide local security.
- . Conduct fire and movement.
- . Reconnoiter a contaminated area." (USAARMC, DTD, 1980) (See also AR 310-25.)

SUBTASK -- "If a task is complex it is also subdivided for clarity and ease in identifying training requirements. The subdivisions of a task are called subtasks." (O'Brien et al., 1975.)

TASK -- ". . . function, procedure or action which a system must accomplish to complete a mission. Tasks are identified and ranked in descending order as duties, tasks and subtasks." (O'Brien et al., 1975.)

These tasks are derived from major mission operations (MISSION PHASES in Drucker and O'Brien, 1981) by grouping major mission operations (MMO) into a predicted sequence of events called a time line (or time line operation sequence) and then identifying tasks for each MMO in the time line. Definition in terms of function and procedure may be arbitrarily limiting in their effects on analysis. The term function is used with several very different meanings in analysis of collective tasks. It is also highly probable that many complex tasks, especially collective tasks are not subject to procedural, i.e., sequential analysis. In such tasks there may be such a variety of parallel, branching, alternative and recycling activities going on simultaneously as to defy a linear model.

TASK ANALYSIS -- ". . . the conversion of task statements into training objectives." (O'Brien et al., 1975.)

"A process of reviewing actual job content and context to classify information into units of work within a job. The process provides a procedure for isolating each unique unit of work, provides a procedure for describing each unit accomplished and provides descriptive information to assist in the design and testing of training products." (TC 350-3.)

TASK CONDITIONS -- "Factors which describe the necessary equipment and physical setting under which the soldier is required to accomplish the specified task on the job. Conditions describe the important aspects of the performance environment." (TC 350-3.)

Task conditions are sometimes defined as narrowly as the organizational context of the unit under analysis, and are otherwise defined more comprehensively as the threat, weather, terrain, doctrine and equipment in the tactical context, the whole situation and environment in which the task must be executed. (See also CONDITION.)

TASK SELECTION BOARD -- "A board of personnel (subject matter experts, personnel selected by the School Commandant, and at least one analyst) convened to review the task inventory and select tasks for training for submission to the School Commandant for approval as critical tasks. Guidance for the conduct of this board must be in writing and be maintained in the audit trail for the job and task analysis process." (TC 350-3.)

TASK STATEMENTS -- *Task descriptions for each unit, which include the action, initial and terminal cues, start and end points and product or outcome, along with the conditions and standards of task performance.*

"Duties, tasks and subtasks are shown in the task inventory as task statements. The statements should clearly describe the intended action, should be specific, and should denote a comparable level of activity. Each task statement must have at least two elements: an action verb and an object. Some task statements require an additional element, a qualifier, to adequately describe the intended action." (O'Brien et al., 1975.) (See also TC 350-3.)

TIME LINE OPERATIONS SEQUENCE -- ". . . the time line reflects the sequence of major mission operations (MMOs) during the conduct of a mission. The specific tactical MMO is the focal point in the time line; it indicates the mission in which the system is involved. Taking a tactical MMO (TMMO) . . . and grouping supporting MMOs (SMMO) . . . around the tactical MMO completes the time line. Thus, the time line is the result of connecting SMMOs to a TMMO." (O'Brien et al., 1975.)

UNIT -- *a military organization, such as a Division, Brigade, Battalion or Combat Team, not appreciably lower in echelon than a company or (Cavalry) Troop, to which certain missions are assigned and/or implied by the TO&E and other planning documents. (See MISSION.)*

UNIT SUBTASK -- *a part or phase of a unit task (or collective task) which may be assigned to the same or a lower echelon unit. The unit subtask for the supraordinate organization may become the unit task for the subordinate unit.*

UNIT TASK --- *a task assigned to a specific unit, a specific action to be accomplished by that unit during a specified time period. A unit task is a collective task. A unit task for a lower echelon unit may be regarded as a subtask at the higher echelon level.*

VALIDATED THREAT -- "THREAT demonstrated to be likely as well as known."
(Blau et al., 1980.)

APPENDIX B
BRIEF SURVEY ON ANALYSIS OF COLLECTIVE TASKS

ARI Field Unit-Ft Knox
Steele Hall
Fort Knox, KY 40121
(Dr. Bauer, AV 464-6928/7046)

BRIEF SURVEY ON ANALYSIS OF COLLECTIVE TASKS

The following questions are pertinent to the development of a methodology for analysis of collective tasks (ACT). Please note that only collective or unit tasks are addressed (not individual tasks unless specifically indicated). Please mark the survey as requested and then add any comments, explanations or objections as you wish.

1. For what purposes do you (or does your organization) do analysis of collective tasks (ACT)? Mark in the parentheses . . . rank (1) for predominant purpose, (2) for next most important, (3), (4), etc. until all your purposes are indicated. If your purposes are not listed, describe and rank them under other below.

- () design of organizational unit.
- () allocation of job functions to operators.
- () comparison (matching) of unit and individual training objectives and standards.
- () development of unit training devices.
- () development of unit training (new).
- () development of unit evaluation instrument(s).
- () analysis of existing courses of instruction.
- () other (describe) . . .
- () other (describe) . . .

Comments _____

2. For each purpose ranked in question 1 above, estimate the number of man days per year spent in your organization in (a) development of ACT procedures, (b) analysis and reporting of collective tasks. (Higher man days do not necessarily correspond to higher ranks.)

Man Days		
	(a)	(b)
	Procedures Development	Analysis (ACT) and Reporting
Purpose rank 1		
Purpose rank 2		
Purpose rank 3		
etc. _____		

3. For each analysis job (e.g. organizational unit analyzed) estimate the total number of man days (average) used.
-
4. What organizational unit(s) are the principal focus of your ACT? Please rank order (1), (2), etc.
- () Division
 - () Brigade
 - () Battalion (Squadron)
 - () Company (Troop)
 - () Platoon
 - () Other (describe) . . .

5. Where and how did your Collective Analyst personnel receive training in ACT?

- _____ OJT with guidance from a more experienced person.
_____ OJT with little or no guidance.
_____ correspondence or self-taught course.
_____ formal instruction (identify course name and place).
_____ Other (describe) _____

6. Suppose that a methodology has been developed (including definitions of terms, general rules and principles of procedural development, but not the specific procedures for analysis). Which of the following criteria would be most important in determining the merit (value) of the methodology? Place rank order in parentheses, e.g. (1) for most important, (2) for next most important, (3) next, etc., until the last (least important characteristic) has been ranked (5). (See definitions below.)

- () Economy/Efficiency
() Utility/Relevance
() Simplicity
() Adaptability
() Acceptance

Comments _____

DEFINITIONS

Economy/Efficiency--Is the methodology reasonably economical? Can procedures be derived and analysis executed in a reasonable time by one or two persons (with minimum training)?

Utility/Relevance--Does the methodology provide guidance useful and pertinent to analysis of collective training?

Simplicity--Is the methodology such that, with minimum training and/or a training aid, the analyst can understand and apply the methodology to derivation of a procedure and analysis of unit operations?

Adaptability--Is the methodology flexible enough that different scopes and procedures can be derived for different analytic purposes?

Acceptance--Will you (or your collective analyst) use this methodology?

7. Who is your organizational POC for ACT? Identify by title and AUTOVON phone, please.

Title:

AUTOVON:

8. Are you, yourself, working as a collective analyst? ☐ Yes ☐ No

Return completed Survey to:

Chief
ARI Field Unit - Fort Knox
Steele Hall
ATTN: PERI-IK (Dr. Bauer)
Fort Knox, KY 40121